



Research Department Report

A STUDY OF SOUND BALANCES FOR THE HARD OF HEARING

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Summary

Over a period of years, complaints have been received from television viewers, especially those who are hard of hearing, that background sound (e.g. audience laughter, crowd noise, mood music) is often transmitted at too high a level with respect to speech, so that information essential to the understanding of the programme is lost. To consider possible solutions to the problem, a working party was set up representing both broadcasters and organisations for the hard of hearing. At early meetings it was resolved that a series of subjective tests should be carried out to determine what reduction of background levels would be needed to provide a significant improvement in the intelligibility of television speech for viewers with hearing difficulties. The preparation of test tapes and the analysis of results were undertaken at Research Department, and are described in this Report.

Index terms: *Hearing; speech*

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1. INTRODUCTION

1.1 The problem

Many television viewers, especially those who are hard of hearing, believe that background sound effects often obscure speech content which is essential to the appreciation of a programme. Among the examples cited are crowd noise at a football match obscuring the commentator's revelations as to who scored a goal, and 'mood' music in a drama rendering unintelligible a vital comment.

It would often of course be possible to broadcast only speech without background effects. However, for someone with normal hearing, this would result in programmes largely lacking in reality: the importance of 'atmosphere' should not be underestimated. Without some impression of the roar of the crowd at a Cup Final, the emotion of the event could not be conveyed; similarly, in dramatic productions music can greatly heighten the involvement of the viewer or listener. Conversely, for someone with profoundly impaired hearing, any background sounds at all may render speech totally unintelligible.

The broadcasting systems in current use do not have sufficient capacity to cater especially for the hard of hearing, for example by providing a separate sound channel carrying speech only. About 17% of people in Britain suffer from clinically significant hearing loss; the problem of balancing their needs against those of the 'normal' majority has clearly no solution that could satisfy the whole population. At present, therefore, the best that could be done would be to compromise by reducing the level of background effects to an extent that would improve intelligibility for the hard of hearing without destroying programme 'atmosphere' for those who have no hearing difficulty.

1.2 The working party

To determine a realistic course of action, a working party was set up whose members represent the following organisations:

British Association for the Hard of Hearing (BAHoH)
Royal National Institute for the Deaf (RNID)
British Broadcasting Corporation (BBC)
Independent Broadcasting Authority (IBA)
Independent Television Companies Association (ITCA)

The brief was to exchange views, to try to determine the extent of the problem, carrying out tests if necessary; and finally, to make recommendations for broadcasters based as far as possible on convincing evidence.

2. THE SUBJECTIVE TEST PROGRAMME

2.1 Introduction and background

There can be no doubt that excessive levels of background sound impair viewers' enjoyment of television programmes. From time to time, a programme is transmitted with an exceptionally high background level; this invariably results in a number of complaints, not only from the hard of hearing, but also from viewers whose hearing is probably normal.

The need to quantify the problem was recognised at the outset, and the Working Party agreed that if necessary, subjective tests should be set up to try to achieve this.

Before embarking on a test programme, it is of course essential to review the current state of knowledge to check that the answers are not already known. In any research field, and that of speech discrimination is no exception, practitioners try as far as possible to break the problem down into domains sufficiently small that a well-defined test can produce a meaningful result. Because television is a complex medium, where lip-reading is sometimes possible, sometimes not (a distinction usually lost upon viewers with normal hearing), it was recognised that the large published body of highly specialised research data would be very difficult to apply directly.

Given the 'evident' sensitivity of viewers to background level, it was decided that a series of simple tests, in which subjects viewed a selection of representative television programme material, might well provide a reasonable indication of speech intelligibility in the presence of a range of background levels for viewers with a range of hearing abilities.

The programme material was supplied both by the BBC and by Independent Television; the test tapes were compiled by the BBC, and the subjects were recruited by the BAHoH. The results were analysed by the BBC with assistance from the RNID on matters of hearing disability.

2.2 Format of tests

During two meetings at which television programmes were demonstrated with a range of background sound levels, the following test format was evolved by the Working Party.

The test tape should begin with an introduction explaining how to do the tests, and advising subjects to adjust their sets (as well as any other equipment such as hearing aids) for comfortable viewing and listening. The test material would then follow, with each test clearly identified by a caption; ample time would be allowed for subjects to make and record their decisions. The background sounds would be presented at three levels relative to speech: 'normal' (i.e. that determined by an experienced sound supervisor to be typical of what he would wish to transmit), and also both 6 dB louder and 6 dB quieter than this level.

The duration of each programme excerpt would be about 45 seconds; this would provide adequate opportunity for assessment without becoming excessively tedious. To obtain maximum concentration from subjects, the total amount of test material would not exceed about twenty minutes. Subjects would be asked to use whatever equipment they normally used when watching television (e.g. headphones, hearing aid, room or personal loop, etc.). Before viewing the test tape, each subject would be asked to complete a questionnaire designed to indicate his or her probable degree of hearing impairment.

Initially, pilot tests would be made at BBC Research Department with twenty subjects whose hearing had been tested at the RNID; if these produced meaningful results, the material would be distributed on VHS cassettes to members of the BAHoH. As a check, a test similar to the BBC pilot would be carried out at IBA Engineering Headquarters.

2.3 Selection and compilation of test material

It had been agreed by the Working Party that a wide range of programme excerpts should be included; the material was chosen to include news, drama, situation comedy and sport. In its final form the test tape contains eighteen excerpts, with the programme types presented in a pseudo-random sequence as shown in Table 1.

The programme excerpts were chosen from video tapes which had been prepared with separately recorded speech and background effects; thus, the ratio of speech level to effects level could be predetermined accurately. To ensure that subjects' concentration was

Table 1: Programme excerpts used in subjective tests

Excerpt	
1	Drama: <i>EastEnders</i>
2	News: Paris underground strike
3	Sitcom: <i>Valentine Park</i>
4	Drama: <i>Cinderella</i>
5	Sitcom: <i>'Allo 'Allo</i>
6	Sport: Motor racing
7	Sitcom: <i>Valentine Park</i>
8	Drama: <i>EastEnders</i>
9	Sport: Motor racing
10	News: Consultants' protest
11	Drama: <i>Cinderella</i>
12	Sitcom: <i>'Allo 'Allo</i>
13	Sport: Motor racing
14	Sitcom: <i>Valentine Park</i>
15	Drama: <i>Cinderella</i>
16	News: Gas explosion
17	Drama: <i>EastEnders</i>
18	Sitcom: <i>'Allo 'Allo</i>

not excessively disturbed by the discontinuities in programme content, each excerpt was chosen so that it made reasonable sense on its own; in practice, this meant that the duration of the excerpts varied from about 35 to 55 seconds. A ten-second pause was allowed between tests for the recording of results. Obtaining the required number of excerpts from the available material proved in the end to be surprisingly difficult. By chance, exactly half of the excerpts chosen were from BBC and half from ITV programme material.

When the 'raw' test tape had been assembled, the sound channels were re-balanced by a Senior Sound Supervisor at BBC Television Centre to what he regarded as a reasonable ratio of background sound to speech levels. An introduction was added; the facilities to record this were provided by the producer of *See Hear*. The total duration of the tape is 26 minutes, of which the tests occupy about 20 minutes.

2.4 Presentation of multiple background levels

The presentation of the test material is complicated by two factors: the need to present each excerpt with three different background levels, and the need to avoid presenting any excerpt more than once to each subject (because, of course, intelligibility improves with successive exposures). To solve these problems, three test tapes were made, with background levels as shown in Table 2. The background levels are arranged

Table 2
Background levels relative to 'typical' for tapes A, B, and C

Excerpt	Background level, dB		
	Tape A	Tape B	Tape C
1	0	+6	-6
2	+6	-6	0
3	0	+6	-6
4	-6	0	+6
5	+6	-6	0
6	+6	-6	0
7	-6	0	+6
8	+6	-6	0
9	0	+6	-6
10	-6	0	+6
11	0	+6	-6
12	-6	0	+6
13	-6	0	+6
14	+6	-6	0
15	+6	-6	0
16	0	+6	-6
17	-6	0	+6
18	0	+6	-6

in pseudo-random order on each tape, and the three tapes include in total all excerpts at all background levels. A disadvantage of this splitting of material is that to obtain meaningful results, the numbers of subjects tested with each tape need to be reasonably comparable. This topic will be discussed further later.

2.5 Recording of subjects' test scores and personal data

Each subject was presented with a scoresheet and questionnaire consisting of three A4 sheets as shown in the Appendix. After a brief introduction which explains the purpose of the tests and assures subjects of anonymity (no names are asked for), a series of questions is presented. These have been designed by the RNID to elicit as much information as possible on subjects' likely degree of hearing impairment, and on the particular problems they experienced in television viewing.

Subjects were asked to record their judgements using the CCIR 5-point quality scale as follows:

- 5 Excellent
- 4 Good
- 3 Fair
- 2 Poor
- 1 Bad

Not only is this a well-proven international standard¹ for subjective test work, but it also allows quick and accurate entry of data into a computer for analysis.

3. RESULTS OF THE TESTS

3.1 Data on test subjects

In all, 336 test returns were analysed; their details are summarised in Table 3. Hearing loss was measured by the RNID only for the 14 subjects with hearing impairment who were tested at the BBC; that of the remaining 322 subjects had to be estimated from their returned questionnaires. Given a type of hearing-aid and its typical required volume setting, a fair estimate can be made of its wearer's hearing loss in terms of the standard categories recommended by the British Society of Audiology:

None	<20 dB
Mild	20-40 dB
Moderate	41-70 dB
Severe	71-95 dB
Profound	>95 dB

Not only are these categories very wide, but they give no indication of frequency dependence or of the physical cause of the problem; they are therefore only approximate indicators of disability.

Subject numbers were divided reasonably evenly between the sexes (149 male, 187 female); as the average age of the subjects was just over 60, the slight unbalance might well be attributable to female longevity.

No control was attempted over the numbers of subjects who viewed each tape, other than that equal numbers of cassettes were distributed; the balance of usage was encouragingly even (Tape A, 32% of subjects, Tape B, 32%, Tape C, 36%).

It is worth emphasising that because the subjects were recruited by the BAHoH, the distribution of hearing impairment is very different from that of the British population as a whole. Each subject who carried out the tests at home was requested to invite a friend or relative (not necessarily hard of hearing) to take part; for this purpose a spare questionnaire and scoresheet were provided. Nevertheless, only 28% of subjects had normal hearing, as opposed to 83% of the population as a whole.

Table 3: Statistics of subjects taking part in the tests

Total number of test returns analysed: 336						
Tested at BBC: 43						
Tested at IBA: 39						
Hearing loss	Number of subjects					
	All	Male	Female	Tape A	Tape B	Tape C
None	95	46	49	28	36	31
Mild, aided	12	6	6	3	5	4
Mild, unaided	38	23	15	11	8	19
Moderate	77	32	45	24	23	30
Severe	56	18	38	22	17	17
Profound	58	24	34	20	19	19
All with loss	241	103	138	80	72	89
All categories	336	149	187	108	108	120

Age Group	Number of subjects
20—	1
20-29	21
30-39	19
40-49	33
50-59	41
60-69	110
70-79	79
80+	26
Unknown	6

3.2 Pre-pilot test at BBC Research Department

As soon as the test tapes were completed, initial tests were carried out on 28 subjects recruited from local staff, mostly of non-technical background. None of these was aware of any hearing impairment; their average age was about 37. None reported any difficulty in carrying out the tests.

The results (Table 4) suggested that for viewers with normal hearing, the speech intelligibility of typical television programmes rated as 'good'. Increasing the background sound level by 6 dB resulted in a deterioration of 0.56 grade, and decreasing it by 6 dB resulted in an improvement of 0.26 grade.

On the basis of this evidence alone it appeared that, for normal viewers, speech intelligibility (as perceived rather than as measured) was not greatly

affected by the background levels presented. Because increasing the levels had a greater effect than decreasing them, it was assumed that further increases beyond +6 dB would cause significantly greater degradation; in other words, the levels that are typically transmitted are not very far from the maximum acceptable for most viewers. It had to be assumed that, for those with hearing difficulties, a similar phenomenon would probably occur at lower background levels.

Most importantly, it was shown that the test format seemed not to be causing problems for subjects, and that the results appeared believable in that the perceived intelligibility decreased, albeit slightly, with increasing background level.

3.3 Pilot test at BBC Research Department

Of the twenty subjects recruited by the BAHoH and audiometrically tested by the RNID, only

Table 4: Mean results for subjects with normal hearing, tested at BBC Research Department

Excerpt	Grade for background level at		
	−6 dB	0 dB	+6 dB
1	3.75	3.58	2.88
2	4.25	4.13	3.00
3	4.38	4.25	3.13
4	4.42	4.25	3.75
5	4.13	4.38	3.58
6	3.88	4.50	3.50
7	4.00	3.50	3.25
8	3.88	3.50	3.08
9	4.38	3.42	2.25
10	4.83	4.50	4.00
11	3.88	3.67	2.75
12	4.67	4.50	4.13
13	4.50	3.63	3.50
14	3.75	3.88	3.75
15	4.13	3.50	3.58
16	4.38	4.25	4.00
17	4.17	3.38	2.88
18	4.63	4.42	4.13
Average	4.22	3.96	3.40

Table 6: Mean results for subjects with normal hearing tested at IBA, Crawley Court

Excerpt	Grade for background level at		
	−6 dB	0 dB	+6 dB
1	4.00	3.57	3.00
2	4.33	4.57	3.00
3	4.57	4.43	3.17
4	4.71	4.17	4.43
5	4.17	4.57	4.29
6	4.17	4.71	3.43
7	4.57	3.33	3.43
8	4.17	4.43	3.43
9	4.71	4.29	2.50
10	5.00	4.50	4.57
11	4.71	4.14	3.00
12	4.86	4.33	4.57
13	4.86	4.00	4.29
14	4.33	4.57	3.86
15	4.00	4.29	4.14
16	4.71	4.86	4.00
17	4.14	3.50	3.14
18	4.57	4.57	4.17
Average	4.48	4.27	3.69

Table 5: Mean results for subjects with hearing impairment (all categories) tested at BBC Research Department

Excerpt	Grade for background level at		
	−6 dB	0 dB	+6 dB
1	2.83	1.83	1.00
2	3.33	2.83	1.83
3	3.00	2.67	3.00
4	3.83	2.83	2.33
5	4.00	3.00	2.50
6	2.83	2.17	2.25
7	2.67	3.67	2.33
8	4.00	2.50	2.25
9	2.83	1.67	1.00
10	4.67	4.67	3.50
11	3.00	2.25	1.00
12	3.17	4.33	3.67
13	3.67	2.33	1.83
14	3.83	3.17	2.00
15	3.33	2.83	2.08
16	4.33	4.67	3.83
17	2.67	2.33	2.00
18	3.67	3.33	3.00
Average	3.43	2.95	2.30

Table 7: Mean results for subjects with hearing impairment (all categories) tested at IBA, Crawley Court

Excerpt	Grade for background level at		
	−6 dB	0 dB	+6 dB
1	3.00	2.13	2.50
2	3.67	2.60	2.38
3	3.20	3.13	3.00
4	4.25	3.67	3.00
5	3.83	3.60	3.25
6	3.50	3.40	2.38
7	3.75	3.80	4.00
8	3.67	3.80	2.75
9	3.20	2.63	2.50
10	4.88	4.67	3.60
11	3.40	2.75	2.17
12	4.13	3.83	3.40
13	3.88	3.50	2.80
14	3.67	3.60	2.38
15	2.83	2.60	3.13
16	4.60	4.38	3.67
17	2.88	2.83	2.40
18	3.40	3.63	3.17
Average	3.65	3.36	2.91

fourteen were finally able to attend the test sessions. Of these, eight had moderate hearing impairment, three severe, and three profound.

Again, no-one appeared to have difficulty with the test procedure, and all seemed satisfied that the returned scoresheets accurately reflected their judgements.

The results are shown in Table 5. The average assessment of speech intelligibility for typical background levels was 'fair'; a 6 dB increase in background level resulted in a deterioration of 0.48 grade, while a 6 dB reduction improved intelligibility by 0.65 grade. This appeared to confirm the hypothesis that viewers with hearing difficulties required lower background levels for optimum programme appreciation.

This test, like the early trial, indicated that the subjects felt reasonably comfortable with the test procedure, and that the test results appeared to make sense.

3.4 Tests at IBA, Crawley Court

Although in chronological terms the IBA tests were the last to be carried out, they were conducted under similar conditions to the BBC tests in order to provide a check.

3.4.1 Subjects with normal hearing

As in the BBC tests, subjects were recruited from local staff, all of whom believed their hearing to be normal. Twenty subjects took part, with an average age of 29. The results are shown in Table 6, which bears direct comparison with Table 4.

At 'typical' background levels, the average grade awarded was 0.31 higher than in the BBC test. This difference is small, and could have many causes; the most obvious is that the IBA subjects were on average eight years younger than those tested at the BBC.

The effect on speech intelligibility of changing background levels by ± 6 dB is remarkably similar to that in the BBC test; namely, -0.21 and $+0.56$ grade.

3.4.2 Subjects with hearing impairment

Nineteen subjects were recruited by the BAHoH; their hearing losses as estimated from the completed questionnaires are:

- 1 mild
- 9 moderate
- 6 severe
- 3 profound

The average degree of hearing loss is very similar to that of the corresponding BBC subjects (see Section 3.3).

The results appear in Table 7; comparison with Table 5 shows that the average grade for 'typical' background levels was again higher than that returned at the BBC, this time by 0.41 grade. A 6 dB increase in background impaired intelligibility by 0.49 grade, and a 6 dB decrease improved it by 0.29 grade, a reasonably similar result to that of the BBC test.

3.5 Results for all subjects (including those at BBC and IBA)

82 subjects (25% of the total) were tested at BBC and IBA centres under known conditions. The remaining 254 carried out their tests either in groups at BAHoH meetings or individually at home, and therefore under relatively unknown and uncontrolled conditions. In this section the results discussed relate to all subjects; it is instructive to compare these overall results with the well-controlled BBC/IBA subset discussed in the previous section.

3.5.1 All subjects with normal hearing

The results for all subjects with normal hearing are shown in Table 8. The average grade for 'typical' background levels is very similar to that returned in the BBC and IBA tests, and is close to 'good'. A 6 dB increase in background levels caused a degradation of 0.5 grade, whereas a 6 dB reduction produced an improvement of only 0.11 grade. It is probably dangerous to read too much into differences as small as that between 0.11 and 0.28 grade, but it could be suggested that the ambient noise level in typical domestic surroundings is sufficiently high to limit the intelligibility of television speech even when programme background levels are reduced by 6 dB.

3.5.2 All subjects with hearing impairment

The results for all subjects with hearing loss are shown in Table 9; these are again similar to the corresponding BBC and IBA results. The average grade for 'typical' background levels is close to 'fair'; increasing background by 6 dB results in a deterioration of 0.37 grade, and reducing it causes an improvement of 0.17 grade. Once again, the ambient noise in typical domestic surroundings may reduce the effect of changes in programme background levels, especially reductions.

3.6 Further subdivisions of test subjects

The subjects can be further subdivided into groups with standard categories of hearing loss (see

Table 8
Mean results for subjects with normal hearing

Excerpt	Grade for background level at		
	-6 dB	0 dB	+6 dB
1	3.16	3.14	2.64
2	4.00	3.90	2.71
3	3.68	3.75	2.72
4	4.39	3.97	3.65
5	3.97	4.00	3.71
6	4.00	3.94	3.18
7	3.68	3.39	3.29
8	3.94	3.65	3.04
9	3.45	3.39	2.19
10	4.71	4.58	4.29
11	3.52	3.61	2.89
12	4.36	4.28	3.97
13	4.25	3.69	3.42
14	3.56	3.84	3.39
15	3.47	3.65	3.46
16	4.42	4.43	4.22
17	3.75	3.11	2.89
18	4.13	4.14	3.78
Average	3.91	3.80	3.30

Section 2.5). However, some groups are quite small, and have a sufficiently unbalanced distribution of tapes (A, B, or C) that results for all programme excerpts at all background levels are not available. For this reason, two groups (hearing-aid wearers with mild hearing loss and subjects with profound hearing loss) have been omitted. The remaining results are reproduced in Tables 10 to 12.

The chief feature of these results is that, as would be expected, speech intelligibility at any background level is lowest for the subjects with greatest hearing impairment. There appears to be little consistency in the effects of change in background level.

3.7 Objective measurements on test material

In an effort to shed a little more light on the meaning of the test results, a chart recording was made of the speech and background levels of the test tape. This showed some similarities and some differences between excerpts. The maximum level of speech was very similar for all excerpts, but background levels varied greatly, depending, as might be expected, on the nature of the sound source. For example, the traffic noise in the news reports, and the

Table 9: Mean results for subjects with hearing impairment (all categories)

Excerpt	Grade for background level at		
	-6 dB	0 dB	+6 dB
1	2.55	2.25	1.62
2	2.71	2.88	1.70
3	2.86	2.71	2.56
4	3.46	3.22	2.93
5	3.26	3.08	2.86
6	2.76	2.60	1.97
7	3.05	2.85	2.81
8	3.28	2.92	2.49
9	2.41	1.96	1.67
10	3.96	3.93	3.73
11	2.72	2.61	1.92
12	3.34	3.24	3.36
13	2.90	2.69	2.30
14	3.24	3.25	2.77
15	2.94	2.89	2.86
16	3.81	3.72	3.40
17	3.24	2.69	2.26
18	3.49	3.33	3.04
Average	3.11	2.94	2.57

Table 10: Mean results for subjects with mild hearing impairment (unaided)

Excerpt	Grade for background level at		
	-6 dB	0 dB	+6 dB
1	2.60	2.22	2.00
2	3.50	3.87	2.22
3	3.07	3.00	3.00
4	3.56	4.00	4.13
5	4.00	3.67	3.22
6	3.00	3.60	2.67
7	3.11	3.00	3.27
8	4.50	3.80	2.22
9	2.07	2.44	1.50
10	4.22	4.50	4.67
11	2.53	2.89	2.50
12	3.33	4.00	4.20
13	3.78	2.50	3.47
14	4.00	3.87	2.78
15	3.50	3.47	3.33
16	4.27	4.11	3.50
17	2.89	2.50	2.67
18	3.87	3.33	4.00
Average	3.43	3.38	3.07

Table 11: Mean results for subjects with moderate hearing impairment

Excerpt	Grade for background level at		
	-6 dB	0 dB	+6 dB
1	2.30	2.03	1.30
2	3.40	2.90	1.67
3	2.70	2.57	2.90
4	3.60	2.95	2.60
5	4.00	2.60	2.67
6	3.10	2.90	1.90
7	2.90	3.10	2.60
8	4.00	2.60	2.33
9	3.20	2.07	1.75
10	4.60	3.90	4.10
11	2.80	2.70	1.60
12	3.67	3.90	3.10
13	3.50	3.50	2.70
14	3.00	2.80	2.87
15	2.80	3.80	2.87
16	4.10	4.40	4.00
17	3.27	2.50	2.10
18	3.50	3.70	3.30
Average	3.36	3.05	2.57

Table 12: Mean results for subjects with severe hearing impairment

Excerpt	Grade for background level at		
	-6 dB	0 dB	+6 dB
1	2.00	1.89	1.50
2	3.00	2.33	1.56
3	3.67	2.33	2.50
4	3.00	2.75	2.67
5	3.00	3.67	2.50
6	2.38	2.00	1.89
7	2.78	3.25	3.33
8	4.00	2.67	2.33
9	2.00	1.67	1.75
10	3.89	4.25	3.67
11	2.33	2.22	2.00
12	2.89	4.00	3.67
13	2.78	3.00	1.67
14	3.38	3.33	2.11
15	3.25	2.33	2.22
16	3.33	3.44	4.13
17	3.11	3.50	2.00
18	3.75	3.67	3.33
Average	3.02	2.89	2.51

background noise in the *Eastenders* pub scene maintained very steady levels, between 6 and 10 dB below those of speech for typical transmission. On the other hand, the background sound in the motor racing excerpts varied slowly with time, and frequently exceeded speech level. In the situation comedy excerpts, background level was mainly very low, but made frequent brief excursions up to or above speech level; the resolution of the chart recording was insufficient to determine the effect on speech intelligibility. Clearly, very detailed assessments, both objective and subjective, could be made on the test material; it should however be borne in mind that the purpose of the tests was to provide data on the response of hearing-impaired viewers to typical television programmes.

4. CONCLUSIONS ON THE SUBJECTIVE TEST RESULTS

At the outset, the tests were expected to confirm very clearly the general belief that the intelligibility of television speech is highly dependent on the level of background effects. The results suggest that this belief is mistaken; or that the tests do not show what they purport to show; or that the truth lies somewhere between these two extremes; or finally, that there is some altogether different explanation of the results.

Persons who are hard of hearing depend to a greater or lesser extent upon lip-reading; for this reason, the programme excerpts were chosen to include material which allows lip-reading, as well as material which does not. By taking this into account, the analysis of the results could be greatly extended in complexity. A good reason for not doing so is that (at least as far as the author is aware) lip-reading plays a very small part in speech intelligibility for persons with normal hearing, and the results returned by subjects with normal hearing show scarcely greater dependence on background level than those returned by subjects with hearing impairment.

In the author's opinion, the explanation is as follows. The intelligibility of speech is not *highly* dependent on background level; rather, it really is a slowly-varying function such that background levels would have to be very high indeed to render intelligibility 'bad' for normal viewers, and very low indeed to make it 'excellent' for viewers with profound hearing loss. The 6 dB steps were chosen for the tests because 6 dB was considered to be the greatest reduction that programme makers could be persuaded or compelled to make. Viewers with severe hearing problems may well require a much greater reduction of background level — perhaps in excess of 20 dB².

This would confirm the reply of a number of test subjects, who, when asked what background levels they would like, said 'absolutely none at all'.

Discussion with about 80 subjects, of whom approximately half had normal hearing, has suggested that in all probability, no-one's enjoyment of television programmes would be impaired if background levels which coincide with speech were reduced by up to 6 dB; surveys carried out by BBC Broadcasting Research Department tend to support this conclusion.

It must however be clearly appreciated that any reduction in background level would be possible only in circumstances where the speech and background signals are available with reasonable separation. This excludes many programmes which are not made under the direct control of the broadcaster (such as films and some documentaries), and also excludes many outside broadcasts where the interviewer or commentator is sufficiently close to a source of noise (e.g. traffic, football supporters, racing cars) for his microphone to pick up noise as well as speech.

5. FUTURE POSSIBILITIES

To determine whether a complete absence of background effects would indeed allow viewers with hearing difficulties to achieve good speech intelligibility, a test should be set up in which subjects are presented with two levels of background: 'normal', and none at

all. This would also provide an opportunity to ask the subjects whether they would like to watch television without *any* background effects at all; it seems likely to the author that this choice would be made only by a small minority for whom it was the only way of understanding speech.

If tests confirm that very low levels of background effects are required to enable viewers with severe hearing difficulties to gain maximum information from the speech content of television programmes, some means would have to be found of transmitting speech separately from background effects. To benefit from such a system, viewers would need to use listening aids which did not amplify local ambient noise. The additional sound channel capacity that would be required is very difficult to provide because of the severe constraints on spectrum space in the existing broadcast channels. However, multiple sound channels may well become available as part of future high-definition television services.

6. REFERENCES

1. CCIR, 1986. Recommendation 562: subjective assessment of sound quality. Sixteenth Plenary Assembly, Dubrovnik, 1986. *Green Book*, Vol. X, Part 1, pp 275-279.
2. CCIR, 1989. HDTV sound channel for the hearing impaired. Document 10/314, 11/563 (Study Period 1986-1990).

APPENDIX

Questionnaire and Scoresheet for Subjective Tests

BBC/IBA LISTENING TESTS: QUESTIONNAIRE

If you are taking part in these tests at a BAHoH centre, then all you need is this document, which should consist of three sheets of paper. If you are doing the tests at home, then you should have two copies of this document, and also a VHS video tape. We hope that you might have a friend or relative who is also willing to participate in the tests. This person need not have a hearing problem - we are also interested in the views of people with 'normal' hearing.

If you would be kind enough to complete the questionnaire on these first two pages, this would be very helpful to us. You will notice that we do not ask for your name, so you can be assured that the information will remain confidential.

The video tape begins with an explanation of how to do the tests, and the scoresheet for use with it appears on Page 3.

Thank you for helping us in this work.

Derek Mathers
BBC Research Department

Please circle or underline the correct answers to the following questions, or add your own answers on the lines where appropriate.

1. Age: _____ Sex: M F
2. How would you describe yourself with respect to your hearing? Please circle
 - (a) normal
 - (b) a bit hard of hearing
 - (c) hard of hearing
 - (d) quite deaf
 - (e) very deaf

If your answer to Question 2 was 'NORMAL', then you need answer no further questions.

3. When watching TV what sort of problems do you have? Please list as many items as you can think of, starting with the most important:
 1. _____
 2. _____
 3. _____
 4. _____
4. Without any kind of hearing aid or listening device, can you hear your television *comfortably*
 - (a) When the TV is set for normally hearing people
 - (b) When the sound is a bit louder
 - (c) When the sound is much louder
 - (d) I cannot hear comfortably at any level

5. Do you wear a hearing aid? YES NO
If NO please go to question 10.
6. If you wear an aid, is it a National Health one? YES NO
If YES please circle the model number:
- BE 11 12 13 14 15 16 17
BE 31 32
BE 51 52

7. Do you use the aid with the volume control -

Full on Halfway up Less than halfway up

8. If you have a privately purchased hearing aid, please answer the following questions, even if you also have a National Health aid:

Is your hearing aid worn (a) behind the ear?
(b) in the ear?
(c) as a body-worn aid?

Please tell us the make and model _____

Do you use the aid with the volume control -

Full on Halfway up Less than halfway up

9. Do you wear your hearing aid for listening to TV? YES NO

If NO please say if you use any other form of listening device for TV:

If YES do you use a loop system? YES NO
(i.e. the T position on your hearing aid)

Do you find the loop better than the normal M position on the aid? YES NO

If YES please state why: _____

If you do NOT wear a hearing aid or do NOT use it when watching TV, please answer the following questions:

10. Do you have any device that enables you to listen to TV more easily? YES NO

If YES could you please say what it is and why it is helpful?

SUBJECTIVE TEST - TELEVISION SOUND BALANCES

Test tape (A,B, or C): _____ Date: _____

In each test you are asked to assess the **intelligibility of speech** in the presence of **background effects** according to the following scale:

- 5 Excellent
- 4 Good
- 3 Fair
- 2 Poor
- 1 Bad

Test no.	Score
Introduction	
1	
2	
3	
4	
5	
6	
7	
8	
9	

Test no.	Score
10	
11	
12	
13	
14	
15	
16	
17	
18	

On behalf of both BBC and Independent Television, we would like to thank you for participating in these tests.